

Biomusic: Exploring art-science intersections from ecological listening perspectives as new strategies for music composition

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The relationship between sound, hearing and the environment is a product of the evolution of species that has taken place over millions of years. Each species has developed its own organ that allows it to adapt to the acoustic characteristics of its environment. In the case of humans, listening is one of the ways to relate to our environment and study it through its sounds. Various tools have been used throughout history to imitate and study the sounds of the environment, from musical instruments to measuring tools. In the 20th century, the development of audio technologies allowed the capture of sounds from the environment on fixed playback media. This allowed the study of the environment from its sounds with greater precision, with parameters that go beyond human perception.

During the 1970s, the internationally recognized World Soundscape Project (WSP) was founded by composers Murray Schafer, Hildegard Westerkamp, Barry Truax, Bruce Davis, Peter Huse and Howard Broomfield, who together played a key role in interdisciplinary research on soundscapes. The WSP had a vision of the artist or composer as a person trained in all disciplines of sound.¹ This pioneering work significantly contributed to the later development of fields such as acoustic ecology, ecoacoustics and biomusic. They also generated new paradigms within music composition by integrating the sounds of the environment. Although these contributions have been very valuable, they do not represent the complex panorama of ecosystems in the Global South whose problems go beyond the Western paradigms.

Disciplines such as music composition, musicology, ethnomusicology, and anthropology were born from the European imperial epistemological framework that determines historically how to listen, know, and describe the sonic world and global aural cultures. The colonial framework locates the self in the center to study otherness. Historical Eurocentrism establishes the paradigm of the “exotic” in which the Global South is not considered part of the “universal history” but rather in the margins of the periphery. Eduardo Galeano expressed this marginalization in his poem “Los nadies” [The nobodies] in the following manner:

"They are not, even if they are.
 Who do not speak languages, but dialects.
 Who do not profess religions, but superstitions.
 Who do not make art, but handicrafts.
 Who do not practice culture, but folklore.
 That they are not human beings, but human resources.
 They do not have names, but numbers.
 Who do not appear in universal history, but in the red chronicle of the local press.
 The nobodies. Who cost less than the bullet that kills them."²

Colonialism eliminated knowledge and ways of listening and relating to the world. Nowadays, the impact of colonial practices can be glimpsed in the changes in customs and habits of the communities in the Global South and their ecosystems as they move toward the imposed models of modernity aggravated by industrial processes.

"With the conquest of the societies and the cultures which inhabit what today is called Latin America, began the constitution of a new global power covering the whole planet. This process implied a violent concentration of the world's resources under the control and for the benefit of small European minority – and above all, of its ruling classes."³

Unlike historical racist practices, the 21st century opens new and more inclusive perspectives for sound studies within a global horizon. Emerging disciplines such as acoustemology, ecomusicology, and soundscape studies have increased interdisciplinary perspectives through global environmental awareness.⁴ Nevertheless, there is still a lack of new theoretical and practical contributions from music composition, particularly inclusive approaches that involve ways of listening and living in the Global South within the complexity of their ecosystems and their own narratives.

This chapter discusses ways of listening to environmental sounds from an interdisciplinary and intercultural perspective. Two case studies, based on field practices in Natural Protected Areas in Mexico, describe my contributions as a composer. The chapter also considers the historical influences on soundscape studies and their various colonial, ethical, and environmental conflicts in a specific context. The text is divided into two larger sections. After a brief introduction to the interdisciplinary field of biomusic and my approach to it, I present a case study of the installation *Biomachine Wind Animals*. I then introduce the *Acoustic Ecology Lab in Mexico* and discuss gaps and ethical concerns related to composing with environmental sounds on a damaged planet.

Biomusic

The field of biomusic intersects sound art and biological sciences with the aim of creating new music produced with sounds from non-human living organisms. It is an interdisciplinary area that brings together collaboration, interaction, and knowledge exchange between different perspectives in the sounding world.⁵ The term “biomusic”, was first used at the National Academy of Sciences in Washington, DC in 1986.⁶ As a result, in 2002, Patricia Gray, Bernie Krause, Luise Baptista and Roger Payne founded the BioMusic Program as a research field to study how music-making’s biological and cognitive elements are expressed in relationships and meaning-making in human as well as non-human music-communication systems.⁷ However, biomusic as a creative field was already born at the beginning of the 20th century, with collaborations of scientific and musical methods such as those between Cornell Schmitt and Hans Stadler and between Ludwig Koch and Edward Nicholson.⁸

Through my research, I have divided the broad area of biomusic into two fields – those that have emerged from the sciences, such as bioacoustics and ecoacoustics or soundscape ecology, and those that have emerged from the arts: acoustic ecology, biomusicology, zoomusicology, ecomusicology, and acoustemology. Although each field has an interdisciplinary approach, the objectives, methods, and perspectives are more directed toward the arts or the sciences.⁹

As a composer, my interest in biomusic is to develop collaborative strategies between biologists and artists through field practices for transdisciplinary approaches to interpret, relate, and create within environmental sounds. My work highlights the importance of developing field practices in familiar contexts influenced by Donna Haraway’s concept of situated knowledge.¹⁰ It implies creating new narratives from located experiences to avoid the narratives of “universalism” and the paradigm of the exotic. The experiences I present here are based on collaborative practices with biologists in two Natural Protected Areas in Mexico: Coatetelco Lake in Miacatlán, Morelos, and El Platanal in Sierra Gorda, Guanajuato.

Biomachine Wind Animals

Biomachine Wind Animals is an interactive sound installation centered on the aquatic birds of Coatetelco Lake in Morelos, Mexico. It was developed between 2019 and 2020 with support from the Art, Science and Technology program of Mexico’s National Autonomous University, ACT-UNAM. The project combines ancient technologies inspired by the Andean and Mesoamerican pre-Columbian acoustic mechanical systems, such as whistling vessels and whistle bottles. The biomachines are hybrid

bodies of automated mechanical sound artifacts that move and produce sound in response to light.

The work examines the role of technology in understanding and utilizing soundscapes, particularly in biodiverse and pluricultural countries such as Mexico. Based on fieldwork, collaborative practices are carried out with musicians and biologists to study the sounds of specific ecosystems. The methodology combines biology, bioacoustics, acoustic ecology, and ethnography strategies into five stages. The first stage includes fieldwork research in collaboration with biologists: studying the acoustic territory through listening practices, automated acoustic monitoring, and field recording. The second stage includes audiovisual identification of species, as well as field diaries. The third stage focuses on analyzing the acoustic data in the studio, identifying species through listening, spectrographic analysis, species assessment, description, and classification of the soundscape. The third stage includes selecting the material and the creative design for media transformation. The last stage comprises the creative process of transferring the fieldwork to the artwork.

In 2019, fieldwork was conducted at Lake Coatetelco in Miacatlán, Morelos to study the acoustic signals of aquatic birds. The field trips were conducted together with three ornithologists: Fernando Urbina Torres, a specialist in ornithology and bioacoustics of birds, and biologists Alberto Vadas and Mario Flores. The study focused on the dawn chorus, for which we made recordings of the birdsongs, identifying 80 species. Eight species were chosen for the study of their acoustic signals,¹¹ and eight biomachines were then created for the sound installation derived from the biological and bioacoustic study of these species documented during the fieldwork.¹²

The sound installation reflects on four perspectives: ancient Mesoamerican worldviews expressed through zoomorphic iconography, the ecological and biocultural importance of aquatic birds and their ecosystem, ancient concepts of the indivisible bond between society and nature, and the epistemological encounter and conflict between ancient and new technologies.

Biomachine Wind Animals seeks to exchange knowledge between art and science. The biomachines are automated with biomechanical balancing systems that move the water inside the clay artifacts to activate the acoustic systems by the air pressure. The sound of the whistling vessel is generated when the water fills the acoustic chamber and causes the air pressure to activate the acoustic system of the internal whistles.

Inspired by our nocturnal field research looking for the aquatic birds with a flashlight among the “tulars” (reeds), the sound installation encourages the audience to interact with the space and the biomachines in the dark. The audience walks freely around a dark room with the light on their cell phones, searching for contact with the biomachines. When the light encounters the sensor, the movement is ac-

tivated, generating a balancing system that triggers the sound of the biomachines. The artwork is inspired by the acoustic reaction of birds when they encounter the light of dawn. The sound installation creates an aesthetic experience of listening to natural aquatic environments, evocating imaginary worlds that relate ancient wisdom with contemporary scientific approaches to nature.

The work's context: past and present

Pre-Columbian cultures in Mesoamerica and the Northern Andes were highly knowledgeable about their territory, with an integral perspective of artistic and scientific approaches. Different civilizations developed specific tools to study and represent their relationship with the environment. Nature, society, culture, politics, and religion were part of an integral world vision. Based on this multilayered perspective, ancient cultures represented their vision of the world through symbolic traces, such as zoomorphic iconography. Mesoamerican and Andean ancient cultures developed a wide variety of acoustic systems with symbolic iconography. These sound artifacts are semiotic tools for interpreting the biocultural relation to their territory and the sonic world. Pre-Columbian sound artifacts are epistemologies of listening that represent symbolic traces of how society perceived their acoustic territory and related to non-human aural cultures. Ancient wisdom lives in cultural objects in the form of collective memories. These artifacts are carriers of ancestral “cosmoaudiovision” as a way to listen to the world.¹³

There is no linear connection between pre-Columbian cultures and Mexico's current biocultural richness, rather a complex syncretic pluricultural development. In the case of sound artifacts such as whistling vessels and whistle bottles, their musical origins have been lost due to colonization. Today, they exist only as museum pieces and memories of what was once alive in aural cultures. Our eight biomachines were inspired by these pre-Columbian acoustic systems and collectively created with the zoomorphic iconography of the birds studied during the fieldwork.

When we look at present-day Coatetelco specifically, we are talking about an Indigenous Nahuatl-speaking municipality in Morelos, Mexico, whose vegetation is low deciduous forest. It has a population of 11,347 inhabitants, of which 89% live in poverty.¹⁴ Lake Coatetelco is central to the population as a resource that sustains biocultural activities. Alongside agricultural usage, such as for irrigation and fishing, it is also an essential space for social recreation. The lake is linked to the Indigenous “cosmovision” (worldview) of Coatetelco, as the indivisible bond between society and nature.¹⁵ This relationship is audible in the ordinary soundscape, where the layers of human and non-human cultures coexist. While birdsong is very active at dawn, as the sun illuminates the dawn, it is possible to hear the thumping of fishermen in the boats. Festive activities in relation to religious saints are constant and audible from the pyrotechnics and wind bands. Everything is part of the acoustic and dynamic

ecosystem of Lake Coatetelco. The human activities of the community have an ancient connection with the lake and its biodiversity since the pre-Hispanic periods.

The Indigenous cosmovision lives on in myths and stories to this day, particularly those associated with the local fauna. In the specific case of Lake Coatetelco, the ecosystem's birds and animals are very important as part of the community's cosmovision and livelihood. Moreover, the lake is considered sacred for the Indigenous communities; it is a space where water deities live; among them are the "airecitos or pilachichinques", mythical beings in charge of attracting the rains. The communities continue to worship these deities in the present day.¹⁶

Present day Morelos, the third smallest state in Mexico, is home to an astonishing 39% of the country's bird biodiversity, with a record of 439 documented bird species. Records from Coatetelco indicate 200 bird species.¹⁷ The present study recorded 80 species during fieldwork conducted during the winter migratory season. Of those, 23 species are considered at risk, two are in danger of extinction, six are threatened, and ten are subject to special protection.¹⁸ Out of the eight of these species we chose for the sound installation, one is threatened, *Aramus guarauna*, and one of them is considered a priority for conservation, *Pandion haliaetus*.

Art, a symbolic trace for future generations

The biomachines are hybrid technologies, they are cyborgs in terms of Haraway, not only referring to a creature but to a communication system that problematizes the encounter and epistemological conflict between ancient and new technologies.¹⁹ The materiality of each device differs from the others, pointing to one of the major differences between ancestral and new technologies. Sound artifacts like whistling vessels are hand-made with soil and water from the community's territory. They are hybrid bodies linked to essential elements on Earth, such as water, soil, fire, and wind. The ancestral technologies are semiotic tools that convey a cosmovision of how the community sees, hears and inhabits its territories. The inner poetics of these sound artifacts reveal the deep bond and relationship that ancient civilizations had with the environment.

In contrast, industrial processes generate a disconnection with the territory, creating a curtain between the original mineral extraction processes and the final product, hiding the extractive link to natural ecosystems and their impact on them. Mining is an extractive industrial process implemented to obtain natural resources such as minerals to construct computers, sensors, and mechanisms, equipment often used in artistic installations and electroacoustic music. Extractivism obscures the distribution of these resources under political-economic power systems that have historically generated inequality and socio-environmental injustice. With awareness of these disparities, the construction of the biomachines exhibit explicitly these contrasts within their materials, and the relation with the territory.

In the case of Coatetelco, more than half of the population lives in poverty and mining represents a significant threat to habitats: The population has struggled to defend its territory from Canadian mining companies since 2000. According to To-var-Sánchez, mining produces 65% of the total industrial waste in Mexico.²⁰ Analyzing the historical context of the materials we use in the artwork helps us to understand the social and biocultural landscape of the acoustic territories and ecosystems we inhabit. The sound installation *Biomachine Wind Animals* provides an interactive component with the audience that intends to reflect on the relationship between human and non-human organisms and how these relationships have changed over time. The installation is a conscious transfer from the ancient bonding of sound artifacts with nature toward a mechanical industrial connection within digital technologies.

The work was presented at the Archaeological Museum of Xochicalco between January and February 2020, receiving about 600 local, national and foreign visitors. Lectures and educational events on aquatic birds were held during this time, highlighting the importance of preserving the ecosystem. The project had presentations planned for 2020, but these were cancelled due to the COVID-19 pandemic.

In 2023, I returned to the same site where we had made the field recordings by boat. To my surprise, it was no longer possible to enter that lake section by boat, only on foot. The tulars in the same location at the lake had disappeared; the small aquatic habitat as a bird refuge was gone. Aquatic ecosystems are dynamic, and the lake decreases and increases in size according to the rainy season. However, in this case, the expansion of the tourist trade in the restaurant area changed the land use. This practice has increased the commercialization of local gastronomy, which provides economic subsistence for the inhabitants. However, the uncontrolled change in land use due to urban development, such as restaurants and businesses that attract tourists, impacts biodiversity. Mexico has lost 50% of its natural ecosystems; from 1995 to 2022, 122 acres of low deciduous forest in Coatetelco were lost.²¹

What is the point of artwork inspired by natural ecosystems, if the ecosystems being studied are disappearing? Should art be concerned only with aesthetic elements? In the face of an environmental crisis, how can art act as a catalyst for social change?

Changing my compositional praxis: the *Acoustic Ecology Lab in Mexico*

Influenced by these and similar fieldwork experiences and guided by such questions, I started a project in 2020 to integrate the experience of listening to natural soundscapes with compositional tools and scientific insights in a collaborative, creative and pedagogical way. My intention was to include scholars, performers and the community in the creative process.

The artistic field of composition considers the musical work in the form of score and concert hall presentation to be the final product. As I started studying environmental sounds in natural ecosystems and collaborating with biologists in the field, my relationship with the sounds, the bird species and their habitat changed. It affects my personal aesthetic relation to sound, towards a more empathic relation with the living world and the natural ecosystems. I started to understand the strong bond between the species and their habitat and how every modification to it affects the ecological chain.

My music draws on the fieldwork research across different formats. I wanted to share this experience with the performers and make it a tool for educating new generations into a more empathetic way of creating music. Moreover, I wanted to integrate the community that inhabits the ecosystems we were studying as an essential component of the research and as a way of drawing awareness to our human relationships with natural environments, emphasizing how humans are an indivisible part of them.

I created a project called *Acoustic Ecology Lab in Mexico* (Spanish abbreviation: *LEAM*)²² to encourage environmental sound art that emerges from an ecological notion of sound, considering biological species, ecosystems, and the community as an integral part of the works. One of the central axes of the laboratory is immersive listening to natural ecosystems, paying attention to ecological relationships, the acoustic space, and the species (human and non-human) that inhabit it. *LEAM* was created as a space of epistemological exchange where we work and learn from naturally preserved environments as living laboratories of sound. The *Acoustic Ecology Lab* has so far developed two artistic residencies; the first was in Platanal, Sierra Gorda, Mexico.²³ It featured a collaboration with two biologists (Fernando Urbina and Marina Rivero, a mammalogist and nature conservationist) as well as with Duplum, a contemporary music duo (featuring percussionist Iván Manzanilla and clarinetist Fernando Dominguez). I focused on acoustic ecology in my role as a composer. The second edition was an international exchange between Mexico and Germany.²⁴ It was developed in Yaxunah, Yucatán with two international guests: the flutist Sabine Vogel and the visual artist Judith Egger.

The experiences with *LEAM* show us the importance of relating to the natural world from different perspectives, especially in rural areas in the Global South, where the local knowledge and ecosystems have been erased from historical narratives. The results obtained from these residencies have interdisciplinary outcomes. The scientific insights contributed to the first biological reports made in Mexico from the Platanal, Sierra Gorda, and its species; the community developed artistic practices in collaboration with the students and *LEAM*. Moreover, transdisciplinary pieces were developed through site-specific composition practices.²⁵

Ethical concerns

Animal communication is an interaction process between diverse individuals; listening to their characteristics and context provides an overview of the inherent identity of an acoustic territory. The different field practices have shown me several ways to study the soundscape, document it, and describe these experiences. To understand the complexity of the acoustic territories, studying them in the context is essential. My artwork is the process and the result of working in the field, including the interaction strategies, the narratives of description, and an ecological notion of listening.

During my research, I collaborated with scientists, mainly in Mexico, to study the sounds of the natural world. Through my listening experience in natural environments, I am able to perceive how fast the natural soundscapes are changing and the biological species are being silenced. Furthermore, it is particularly difficult to find natural environments without the intrusion of human anthropogenic noises. Even in the middle of natural protected areas, distant from human urbanization processes, the sounds produced by human technologies can be heard.

However, not all human-nature interactions can be considered intrusive. There are ancestral practices whose aural cultures have an indivisible link between society and nature, which provides identity to the people. The cases of Coatepec, El Platanal, Yaxunah and many other soundscapes in the Global South have a cultural syncretism and colonial past that makes them complex and require broad perspectives that include the community's vision.

That is why acoustic ecology requires other disciplines and strategies to study complex ecosystems in the Global South. The terminology used to refer to soundscape studies, which broadly divide the soundscape into four categories – biophony, anthrophony, technophony and geophony – is insufficient to describe complex landscapes in these territories. Whereas the relationships between nature and society are inseparable, they are co-dependent and are factors of biocultural identity.

Currently, the environmental impacts and ecological crises transcend geopolitical borders, although since the 1970s the Global North has been developing a greater awareness of them. However, the transformation process of ecosystems in the Global South has increased with late capitalism and its “Great Acceleration”,²⁶ including a global obsessive development of new technologies within the unsustainable continuity of modernity. There exists a broader belief in contemporary societies that environmental conflicts should be addressed through technological solutions, without considering the relation between technological development and environmental impact and deterioration. In 1972 Meadows wrote, “if the present growth trends in world population, industrialization, pollution, food production, and resource depletion continue unchanged, the limits to growth on this planet will be reached sometime within the next one hundred years. The most probable result

will be rather sudden and uncontrollable decline in both population and industrial capacity.”²⁷

Through field practices, my aesthetic interest in environmental sounds changed to a deep concern for understanding the natural-sounding world within the current ecological crisis. Listening shows that human technological footprints are everywhere, even without being seen; the sounds reveal truths about the need to preserve natural ecosystems.

During 2024 Mexico experienced months of drought, which increased the number of fires in the country. El Platanal and Yaxunah, the sites where the *Acoustic Ecology Lab* developed the fieldwork in the two editions, suffered from these fires. The fires and the state of Lake Coatepec were a wake-up call for me. They made me reflect on what we artists take from natural ecosystems for our work. But what do we give in return? What can we give back to the ecosystems as composers or sound artists? How do we generate art that does not promote extractive practices? How to promote art that arises from the exchange with nature?

From this, I consider it a priority to have ethical considerations, where the artist's purpose not only culminates in the work of art but also in the process of socializing knowledge to different audiences. This involves generating collaborative and interdisciplinary efforts with intercultural exchanges. It is essential that contemporary composers working with environmental sounds today face the environmental crisis with an awareness of a global horizon. The horizontal exchange between the Global North and South should be encouraged and strengthened through empathetic practices with an awareness of the disparities of social and historical injustice. This also includes being involved with the ecosystems and the inhabitants of the place where we work. In this sense, art could become a key for exchanging knowledge and a catalyst for environmental and social change.

Conclusions

My research is informed by ancient listening cultures' relationships with environmental sounds as a source of inspiration for new music. However, the narratives with which history is described depend on specific socio-cultural, political, and economic contexts. For these reasons, fieldwork in specific and familiar contexts is fundamental in addition to theoretical and historical research.

As a composer and sound artist, my intention is to generate a critical reflection on the tools we use as artists. What has been the historical process of these tools as semiotic materials to produce knowledge, and what is the legacy we inherit to future generations? For me, it is important to have an overview of the past and to understand the complexity of the ecosystems where I live and work, in which my

work encourage debate towards envisioning various future scenarios for the next generations.

For me, music composition is not only what happens in the concert hall and is printed on the score. That is one part of it, but music composition is also the process of creating with/through sound. When working with environmental sounds, there are many ways to relate to the sound and the environment and create with/through it. Exchanging knowledge between performers-composers, disciplines, and audiences enriches our relation to the sounding world and our approximation with the work of art.

As a composer, I believe that starting an artwork requires an epistemological review of its intention, methods and working processes. After years of research and fieldwork, I firmly believe that composition drawing on the concept of biomusic and integrating environmental sounds and acoustic signals of different species must reflect not only on the aesthetic but also on the ecological, political and economic aspects inherent to it. In this way, we can be aware of our aesthetic and political positions as social actors. Particularly in contemporary music, unlike popular music, it is not made to entertain; on the contrary, it contributes to the aural experience and the critical reflection of our relationship with sound and our environment.

Understanding sounds in the environment through an ecological notion of sound provides an overview of a landscape's acoustic characteristics in relation to its species and acoustic spaces. Sounds in natural ecosystems are not isolated entities. Every sound has a meaning and a biological function. Listening offers a deeper insight into sound phenomena and their behavior. Fieldwork provides a profound comprehension of the environmental sounds, understanding that it is not only a physical acoustic world. The sounds in the environment are a complex network of interconnected lives of thousands of beings, each of them with a unique voice, culture, language, and a completely different way of relating to the sounding world. In this sense, the artwork is an essential and sensitive tool to create respectful and empathetic approaches to every organism, human and non-human. Finally, I consider that creativity and imagination are together the strongest apparatus to envision a common global and interspecies future.

Notes

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- 8 For further information on the subject, please review Rubio, T.: "Biomúsica: Estudio interdisciplinario", pp. 106–107.
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- 13 I propose the term "cosmoaudiovision", as a complex ideological universe that transfers the essential relationship between sound and deep listening represented in the sound artifacts where the zoomorphic iconography represents the symbolic universe and connection between humans and their natural environment. Rubio Sánchez, Tania L.: "La creación de una obra transdisciplinar contemporánea a partir del estudio y construcción de instrumentos autócto-

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